Leaf Area Index Estimation from Hyperspectral Data using A Group Division Method

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Introduction

Automatic survey over the growth status of paddy-rice in the wide area is very useful for estimating the yield and evaluating the farm environment. Since it is known that the yield and the Leaf Area Index (LAI) are related, estimating LAI from spectral reflectance data is our current purpose of the analysis. We measured paddy fields using an airborne hyperspectral sensor AISA and a field-portable LAI meter. It is necessary to extract the characteristic index from enormous data. Therefore, we propose a new technique in this paper and try to estimate LAI value by choosing a few bands thereby.

Proposal Technique

In this paper, we propose a Group Division Method for the determination of the adequate index. When we have the ground truth data such as LAI, this method determines an index with effective utilization of those data. It consists of two stages, "the group division" and "evaluation of rank disorders in the group". In the First stage, the ground truth data is sorted and divided into some groups depending on the measured LAI value, and examine whether the result of sorted hyperspectral data using some kind of index is related with the ground truth data's groups. With respect to the index that exhibits strong correlations, we calculate the difference of the order in those divided groups as the next step. If all the groups have same elements between the ground truth data and hyperspectral data, the rank difference can be calculated as the grand total that squared the differences. However, there remains a possibility that the group division method cannot find the index which matches all the elements. Then, the weight is multiplied when there is an exchange over groups. The index that shows the smallest value is extracted. The flow chart is shown in Fig.1.

Experiments

In the experiment, we use the normalized difference ND over 2 bands, or the second derivative SD approximated by the triangle formed by selected 3 bands (Fig.2) for making index. Those definitions are shown as,

$$ND_{xy} = (Ry-Rx) / (Ry+Rx) \quad (1)$$

$$SD_{xyz} = (ND_{yz})/\Delta yz - (ND_{xy})/\Delta xy \quad (2)$$

where $R\lambda$ is the reflectance at λnm, and the $\Delta\lambda\mu$ is the wavelength gap defined by $\Delta\lambda\mu = |\lambda-\mu|$. As the result of training from the experimental fields AR1 and AR2 (Fig.3), the index given by 545nm, 1170nm and 1290nm is useful for estimating the LAI. Therefore, the LAI can be estimate by the equation:

$$eL = (R1290-R1170) / ((R1290+R1170) * 120) - (R1170-R545) / ((R1170+R545) * 625) \quad (3)$$

Thus we applied this index to another rice field AR3 and demonstrated the effectiveness. Fig.4 is the graphic representation about ground truth data (Table.1), and the result of the Equation 3 is represented graphically in Fig.5. The water pass exists in the north-to-south direction. Because the LAI concerned with the water temperature and nutrients, similar characteristic was observed along the line. The result shows the same features in each line, respectively.

We are acquiring hyperspectral data and LAI data of Furukawa, Miyagi prefecture and will show the estimation results on several more cases to discuss the availability of this method.

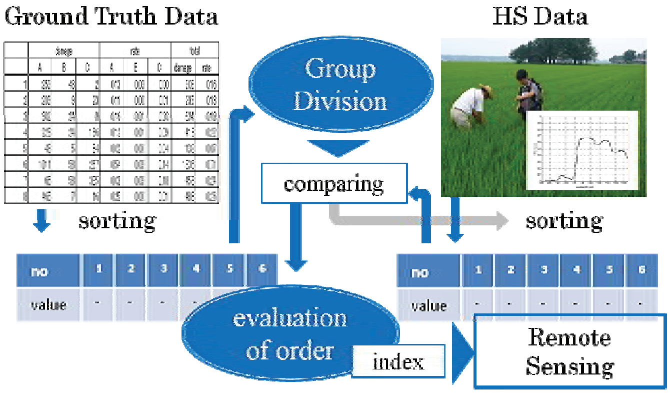

Figure1: flow chart

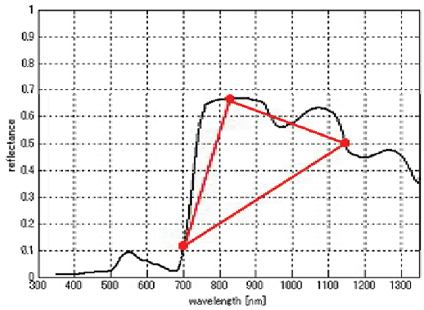

Figure2: 2nd derivative

Table1: Ground Truth Data

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
LAI value	3.75	3.69	4.00	3.79	2.74	2.81	2.88	2.97	2.62	3.39	3.98	4.26	3.35	3.64	3.96	4.10

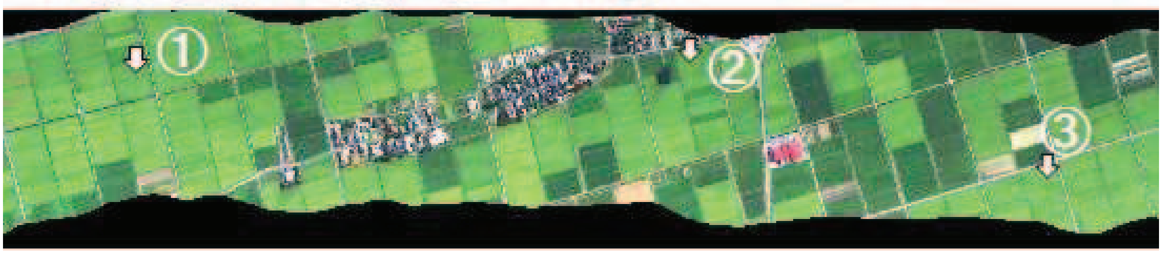

Figure3: Photograph from air plane (Hirono, Yamagata Pref.)

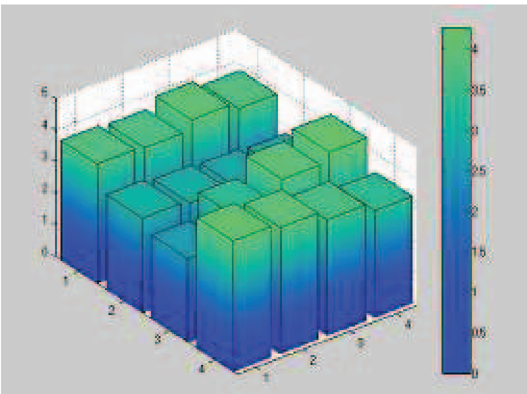

Figure 4: Ground Truth Data

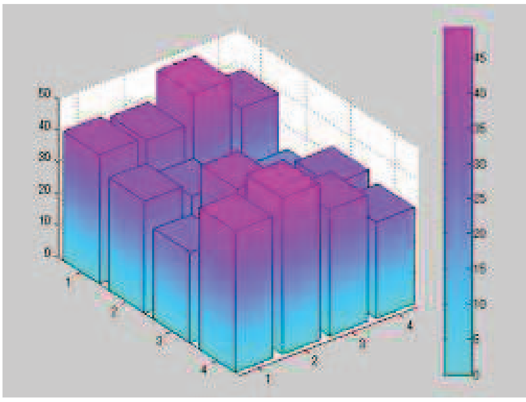

Figure 5: R1290-R1170-R545